

Composite Cloud Particle Spectra from the WB57F

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Need for Composite Spectra

Cloud particle size range ($\approx 1 - 1500 \mu\text{m}$) is not covered by any of the 5 spectrometers.

CAPS (Cloud Aerosol Precipitation Spectrometer)

$\approx 0.5 \text{ to } 44 \mu\text{m}$ (CAS)

$\approx 50 \text{ to } 1500 \mu\text{m}$ (CIP)

SPP-100 (Signal Processing Package Model 100)

$\approx 5 \text{ to } 57 \mu\text{m}$

CPI (Cloud Particle Imager)

$\approx 10 - 300 \mu\text{m}$

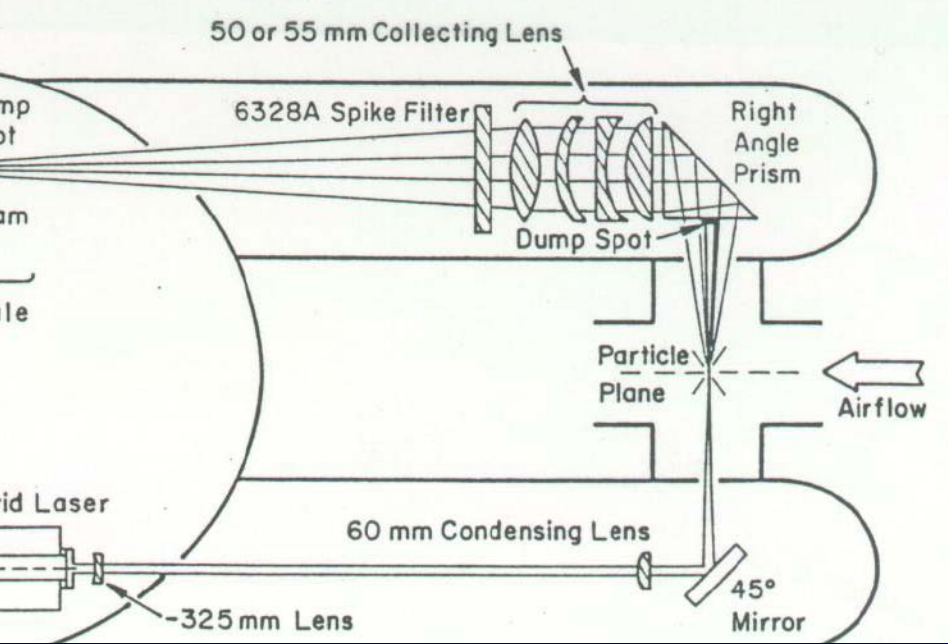
VIPS (Video Ice Particle Sampler)

$\approx 30 - 300 \mu\text{m}$

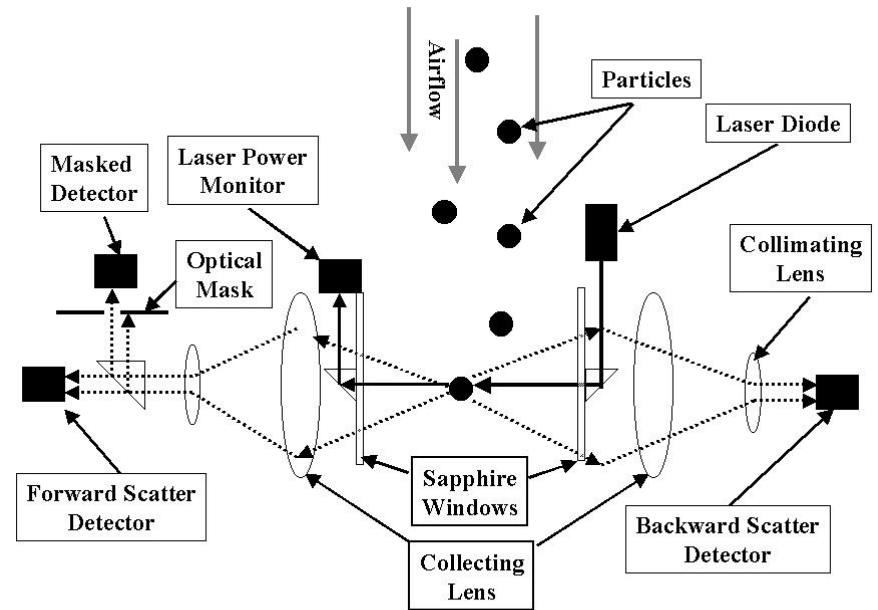
Impact of limitations and uncertainties of each instrument can be reduced with redundancy in overlapping size ranges.

Individual investigators can use their own methodology for combining spectra. The proposed, composite distributions are those that carry the consensus from the instrument PIs with respect to optimum splicing of the information.

SPP-100 and CAS



SPP-100



CAS

Measurement Uncertainties and Limitations

SPP-100

Mie Scattering ambiguities

Electronic response time ($\tau = 0.8 \mu\text{s}$)

Sensitivity of effective beam diameter to particle size

Airflow distortion?

CAS

Mie Scattering ambiguities

Electronic response time ($\tau = 0.2 \mu\text{s}$)

Crystal breakup?

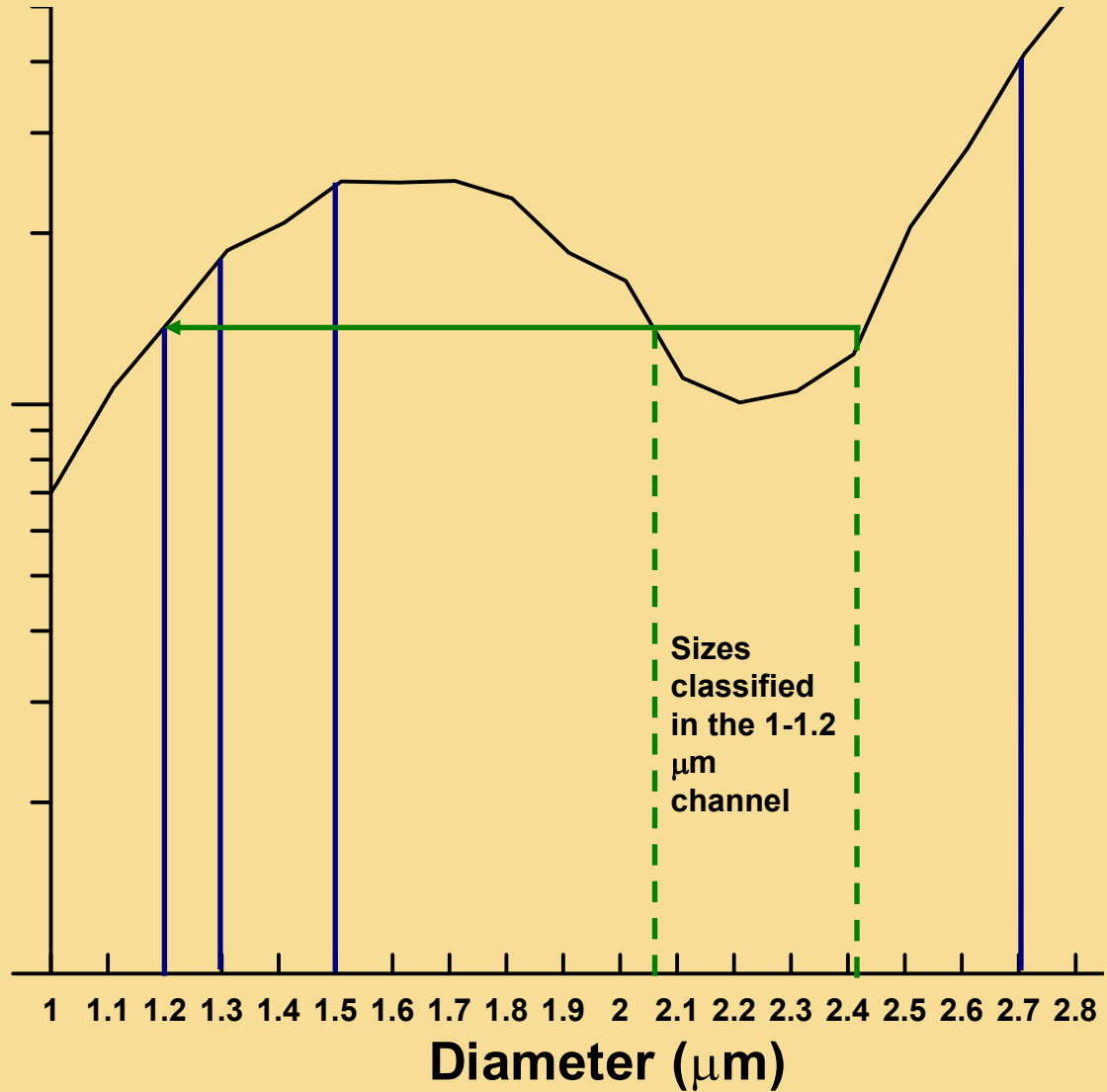
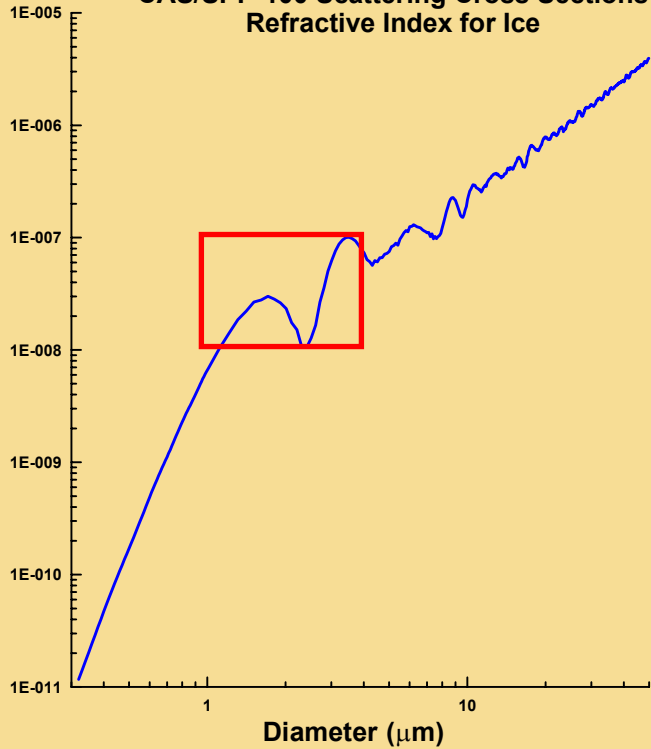
DOF sensitivity to size?

Airflow distortion?

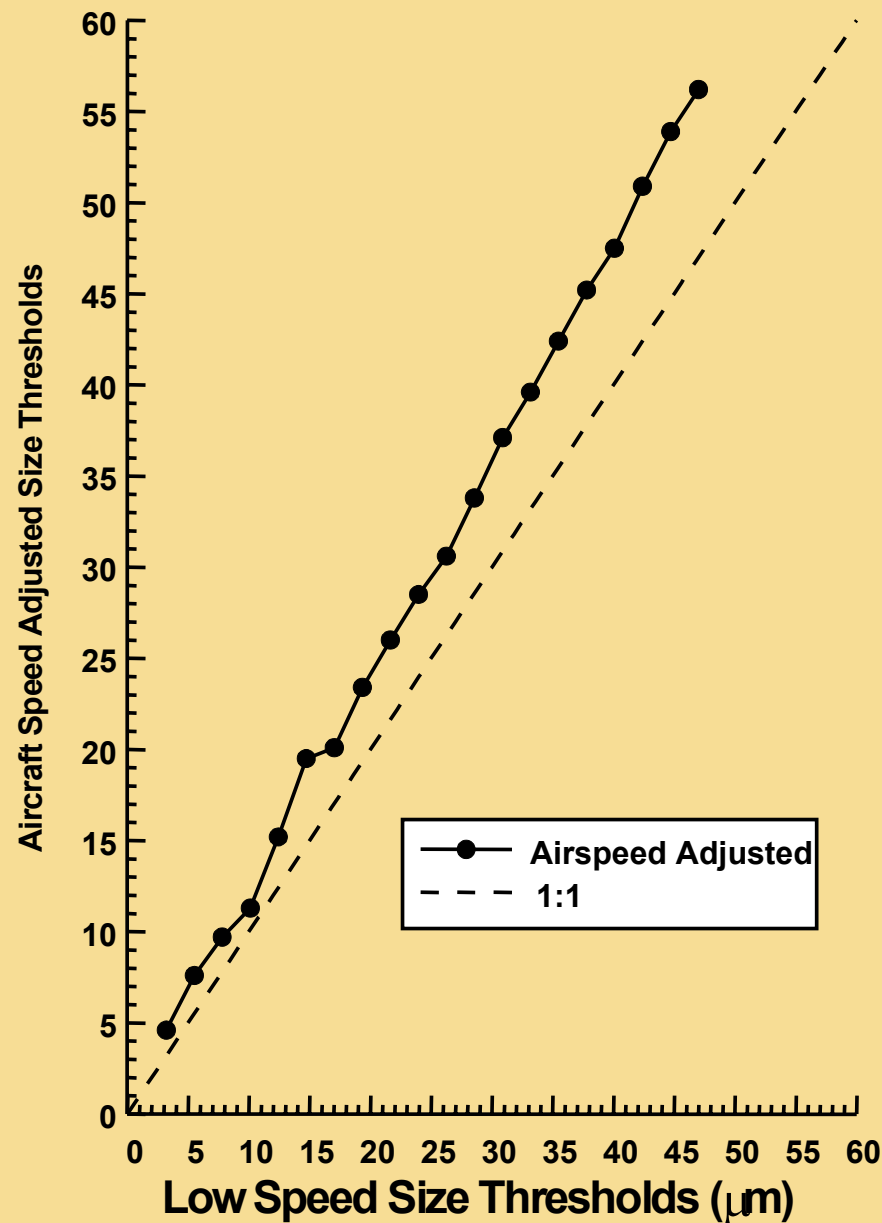
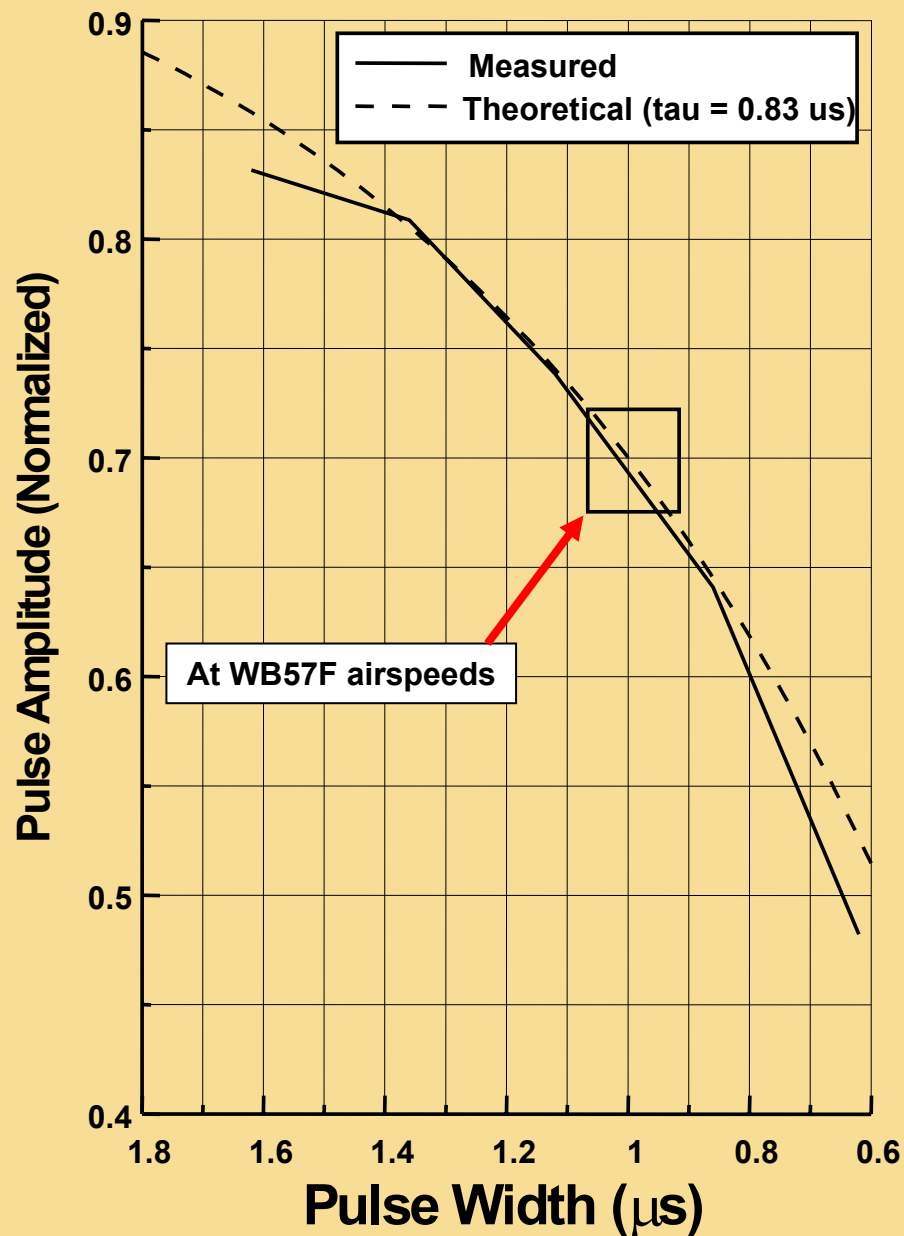
Mie Scattering Ambiguities

CAS/SPP-100 Scattering Cross Sections
Refractive Index for Ice

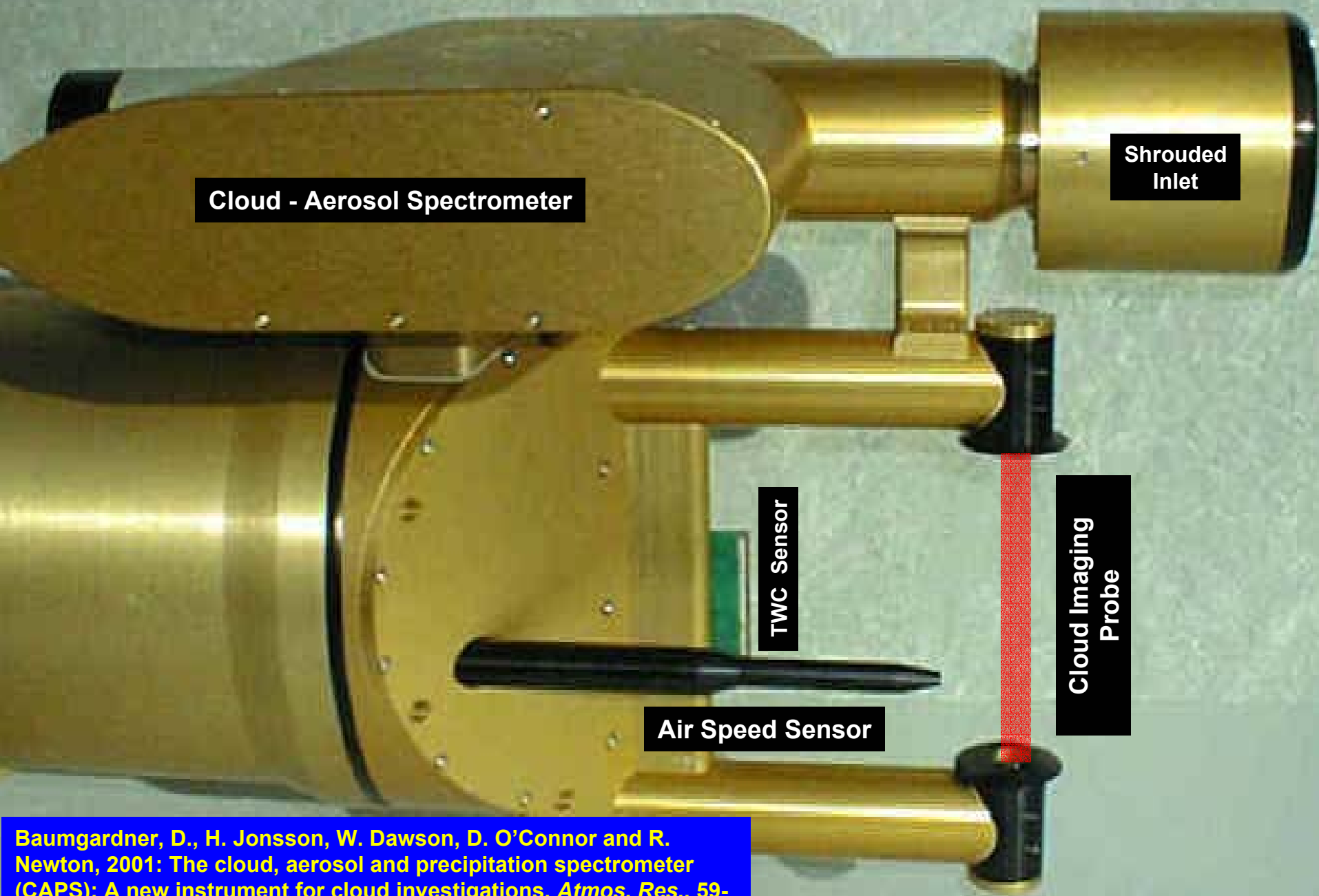
Scattering Cross Section (cm^2)



SPP-100 electronic time response corrections

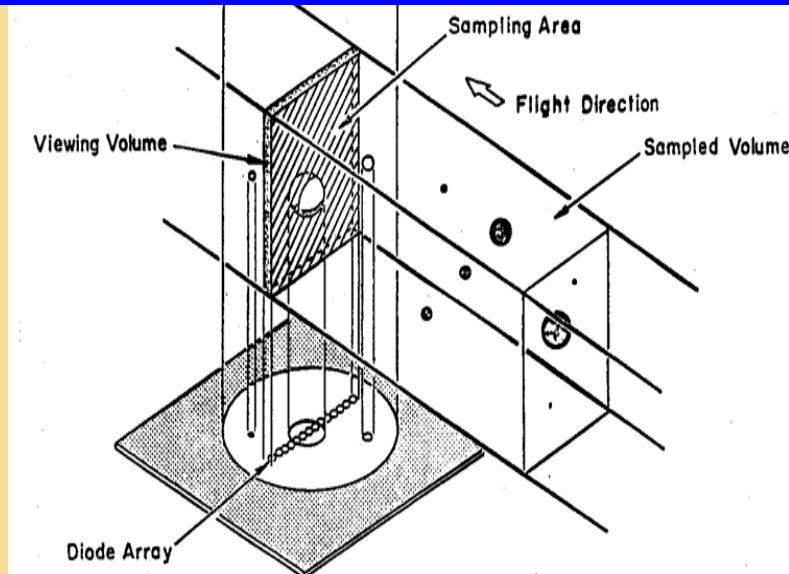
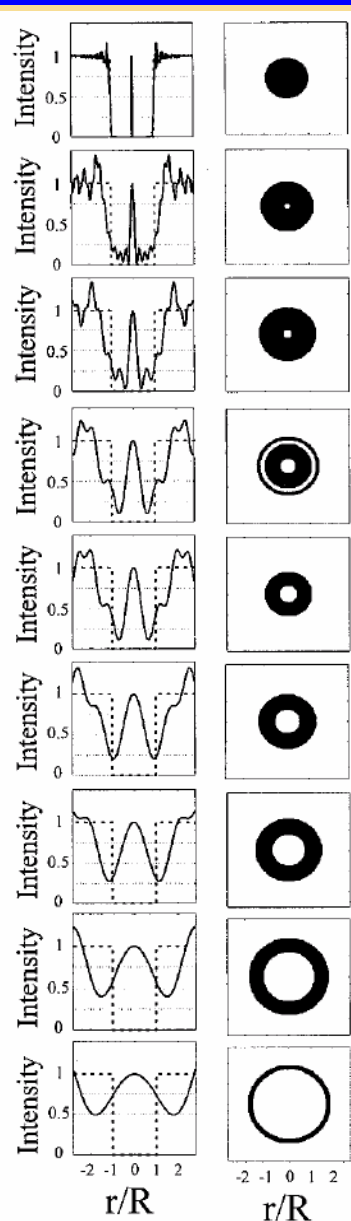


Cloud, Aerosol and Precipitation Probe (CAPS)



Baumgardner, D., H. Jonsson, W. Dawson, D. O'Connor and R. Newton, 2001: The cloud, aerosol and precipitation spectrometer (CAPS): A new instrument for cloud investigations, *Atmos. Res.*, 59-60, 251-264.

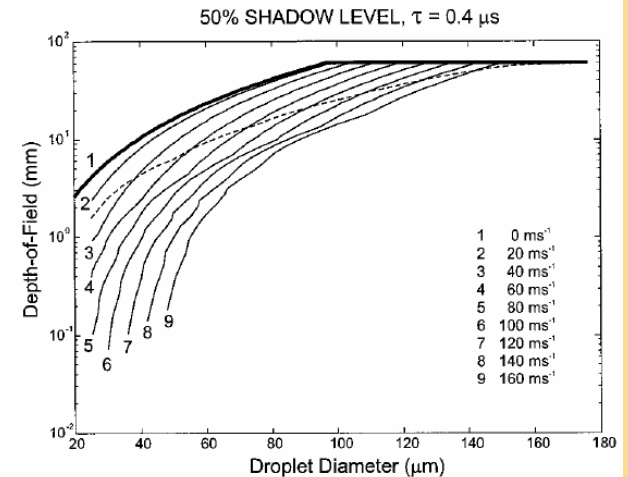
Cloud Imaging Probe (CIP) Basic Measurement Principal and Limitations



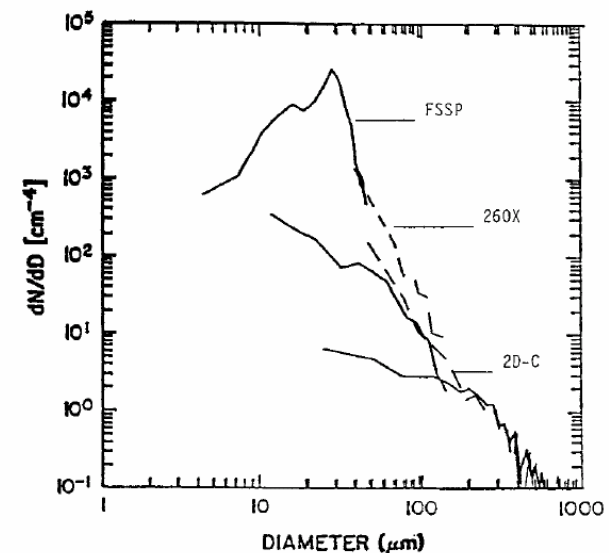
ABOVE
Particles passing through collimated laser are imaged on a linear diode array. 2D image is captured by recording state (on/off) of diodes as array moves in 25 μm steps

LEFT
In-focus images have maximum shadow intensity and same size as object (top). The farther an object is from focal plane, the less intense the shadow and larger the deviation from actual size (lower panels).

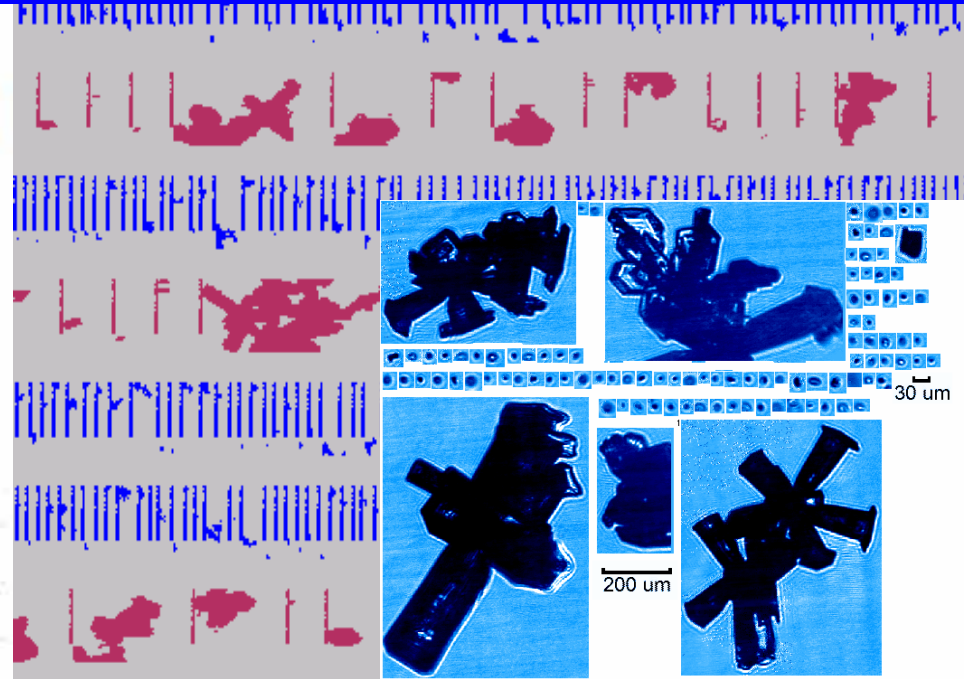
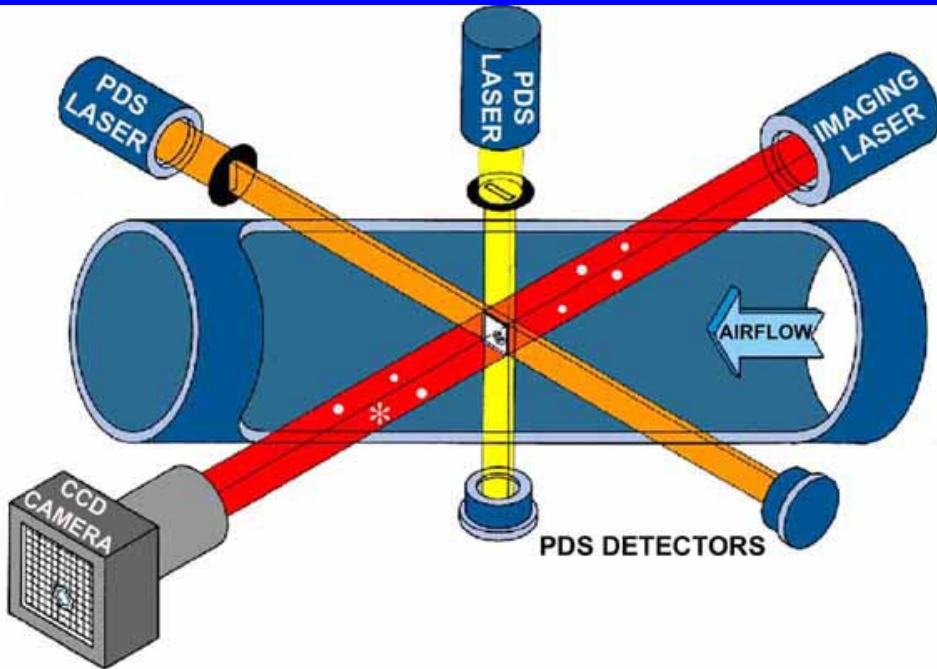
Right
Imaging probes will underestimate particle concentrations if corrections are not applied for the DOF dependency on airspeed. The figure shows comparisons of two imaging probes with an FSSP with corrections (dashed) and without (solid).



The DOF varies with size and airspeed. The electronic response time imposes the smaller DOF as particles must pass closer to center of focus to still shadow at 50%



Cloud Particle Imager (CPI)



Measurement Uncertainties and Limitations

Size range dependent on trigger threshold

Dead-time Losses

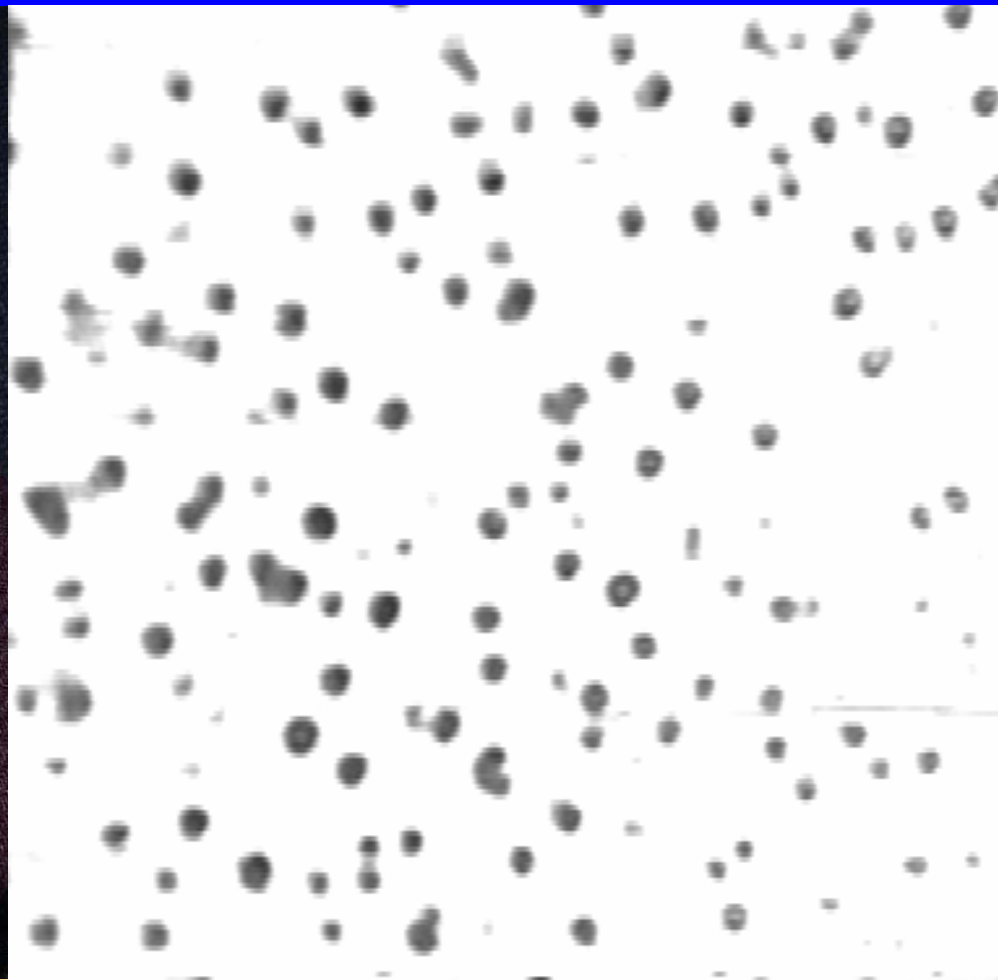
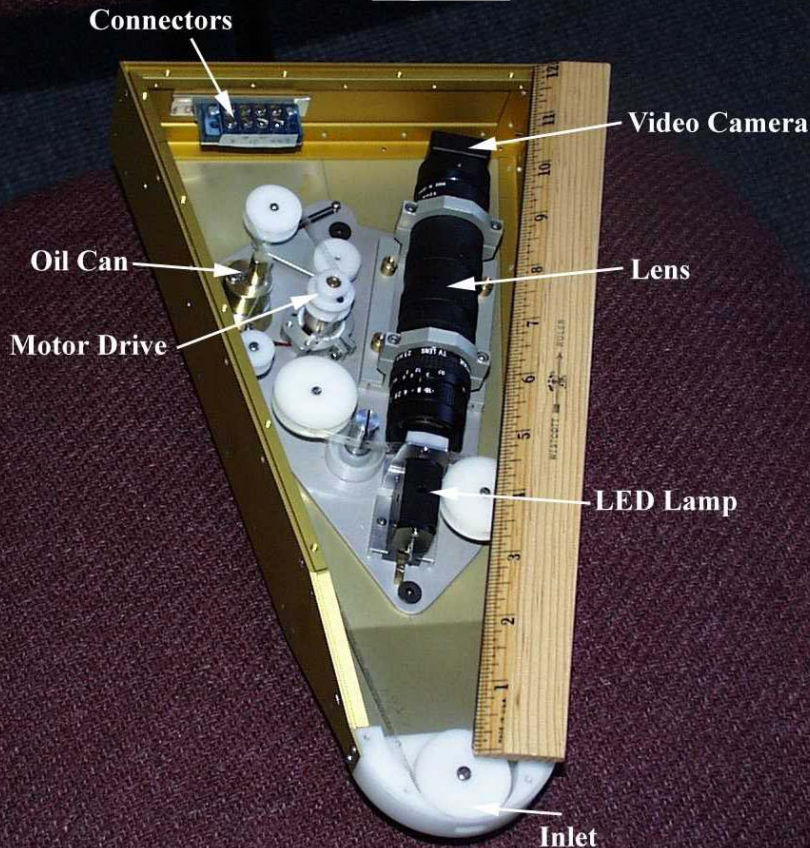
Attack/Sideslip Sensitivity and Crystal Breakup?

Lawson, R. P. and R. H. Cormack, 1995: Theoretical design and preliminary tests of two new particle spectrometers for cloud microphysics research. *Atmos. Res.*, 35, 315-348.

Lawson, R. P., A. V. Korolev, S. G. Cober, T. Huang, J. W. Strapp and G.A. Isaac, 1998: Improved Measurements of the Drop Size Distribution of a Freezing Drizzle Event. *Atmos. Res.*, 47-48, 181-191.

Video Ice Particle Sampler (VIPS)

Top View



Measurement Uncertainties and Limitations

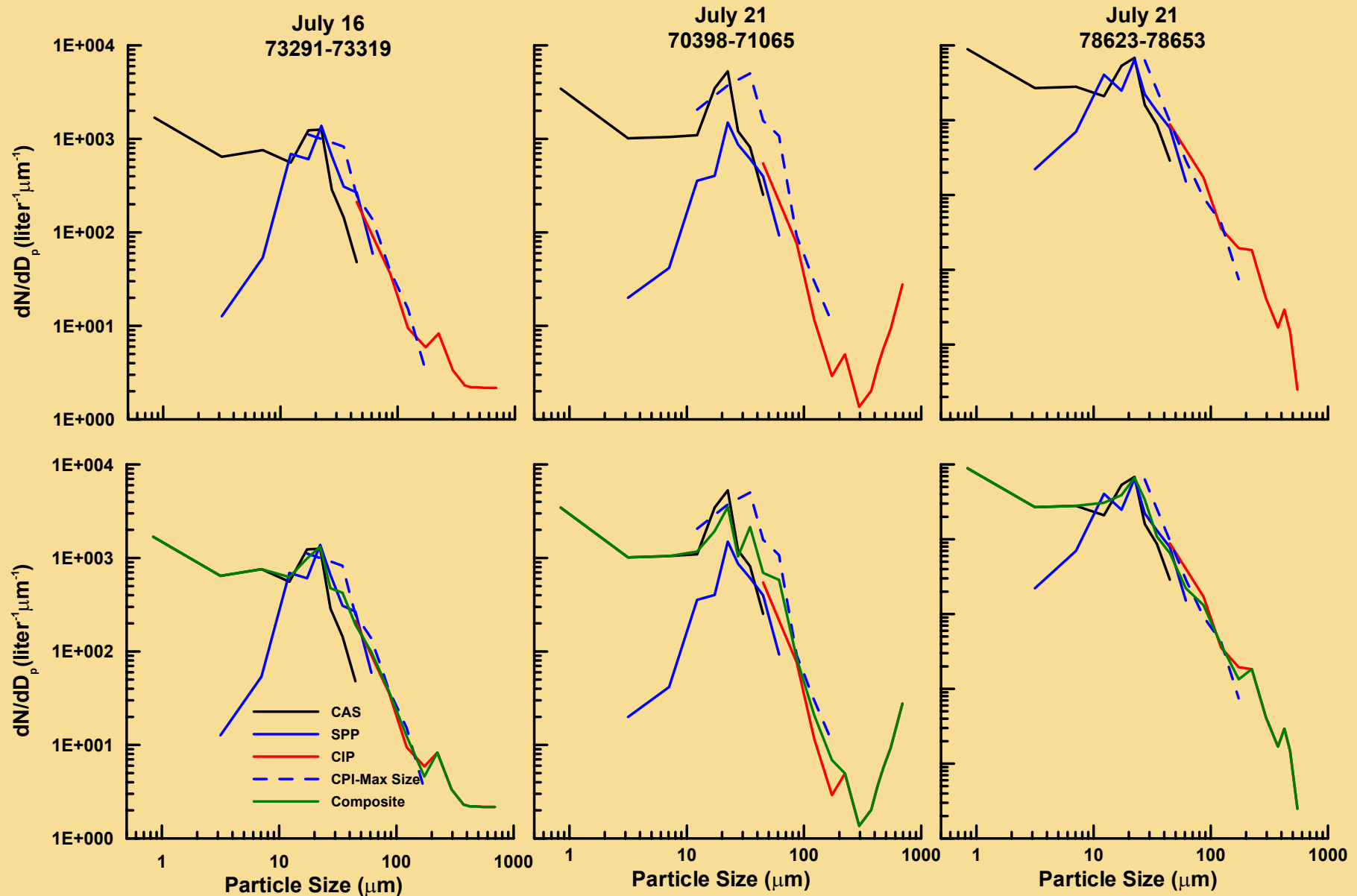
Collection Efficiency limits lower size sensitivity ($\approx 30 \mu\text{m}$?)

Sensitivity to flow angles?

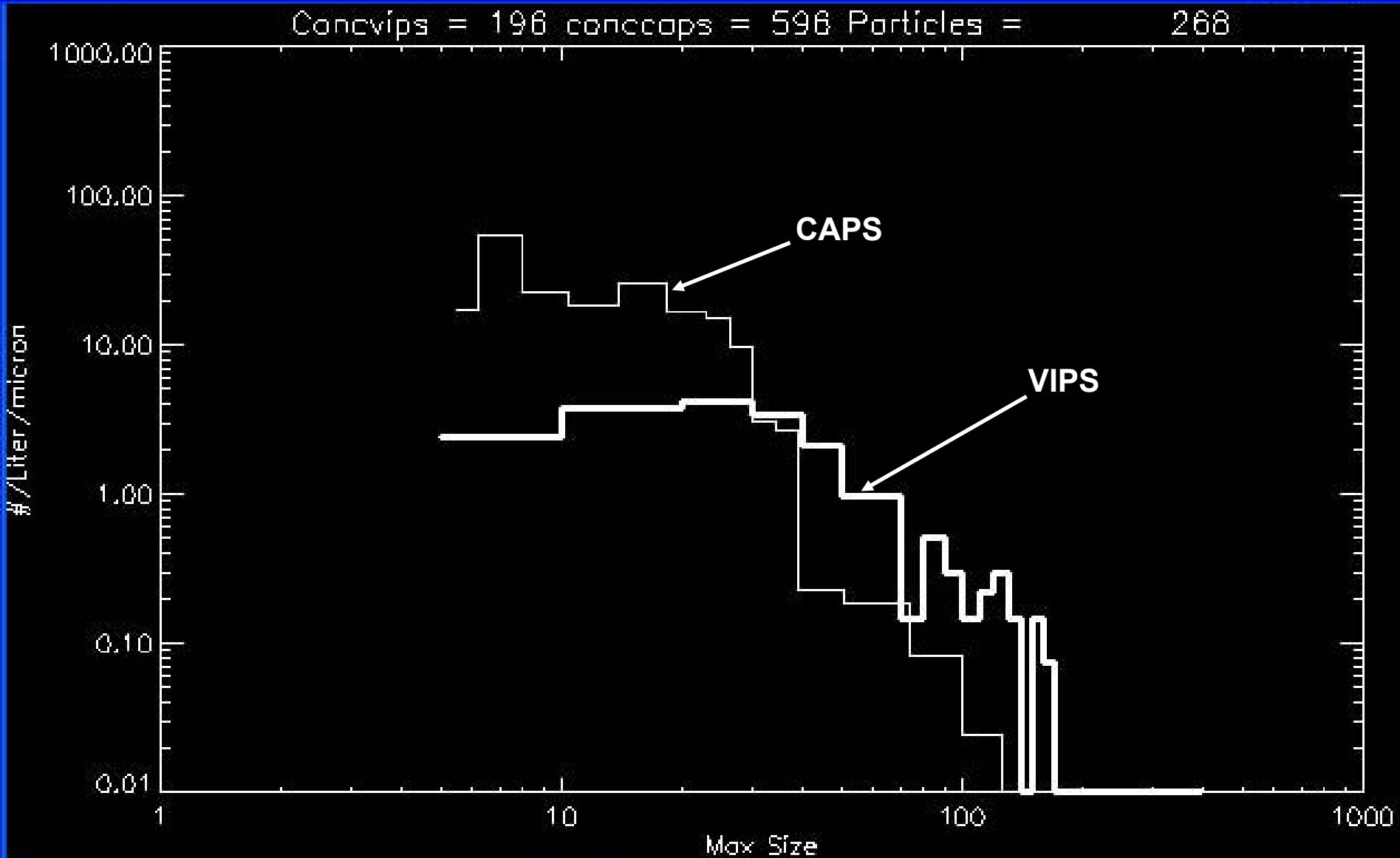
Break-up of larger crystals?

Cloud Spectra Composite Examples

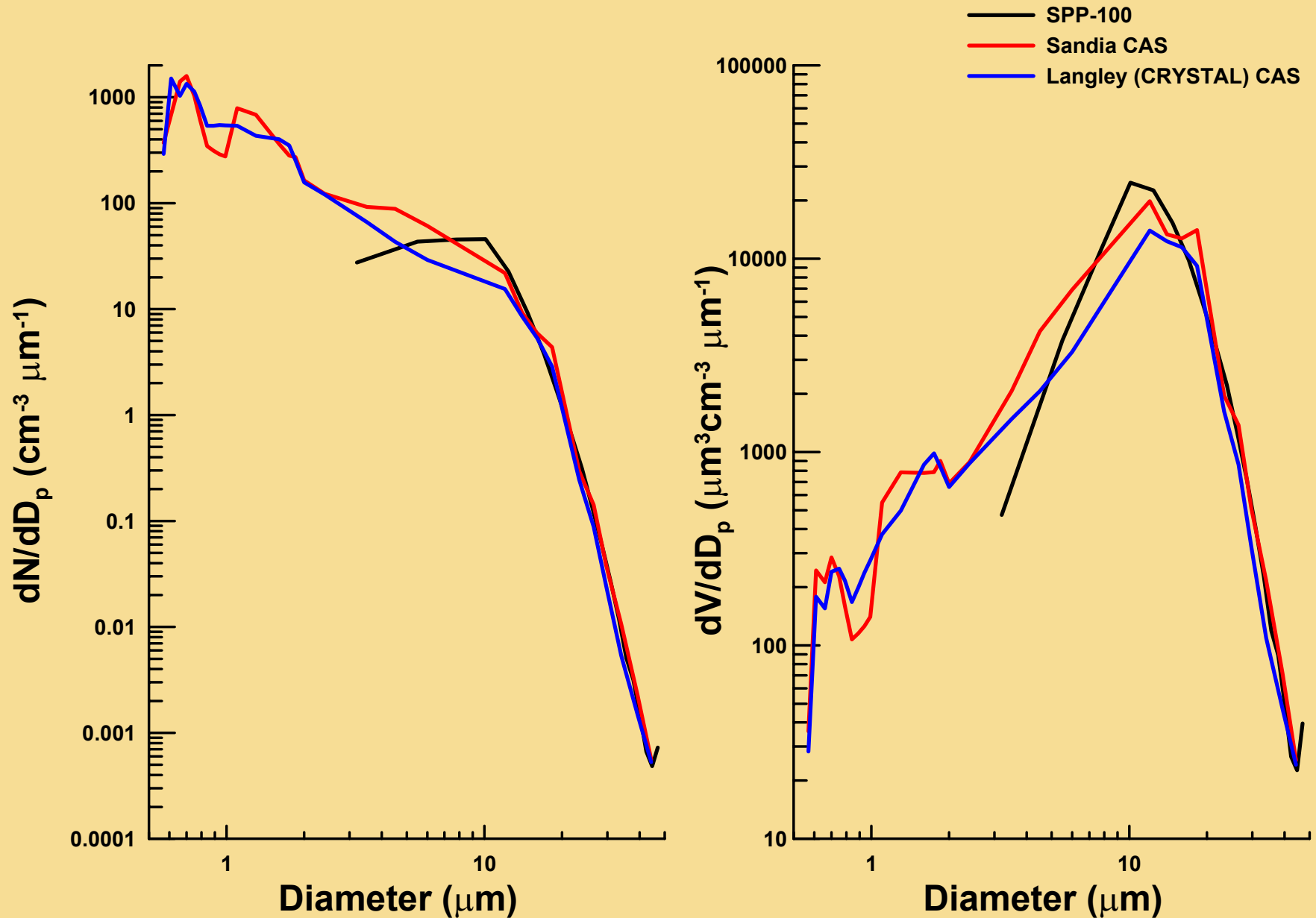
CAPS, SPP and CPI



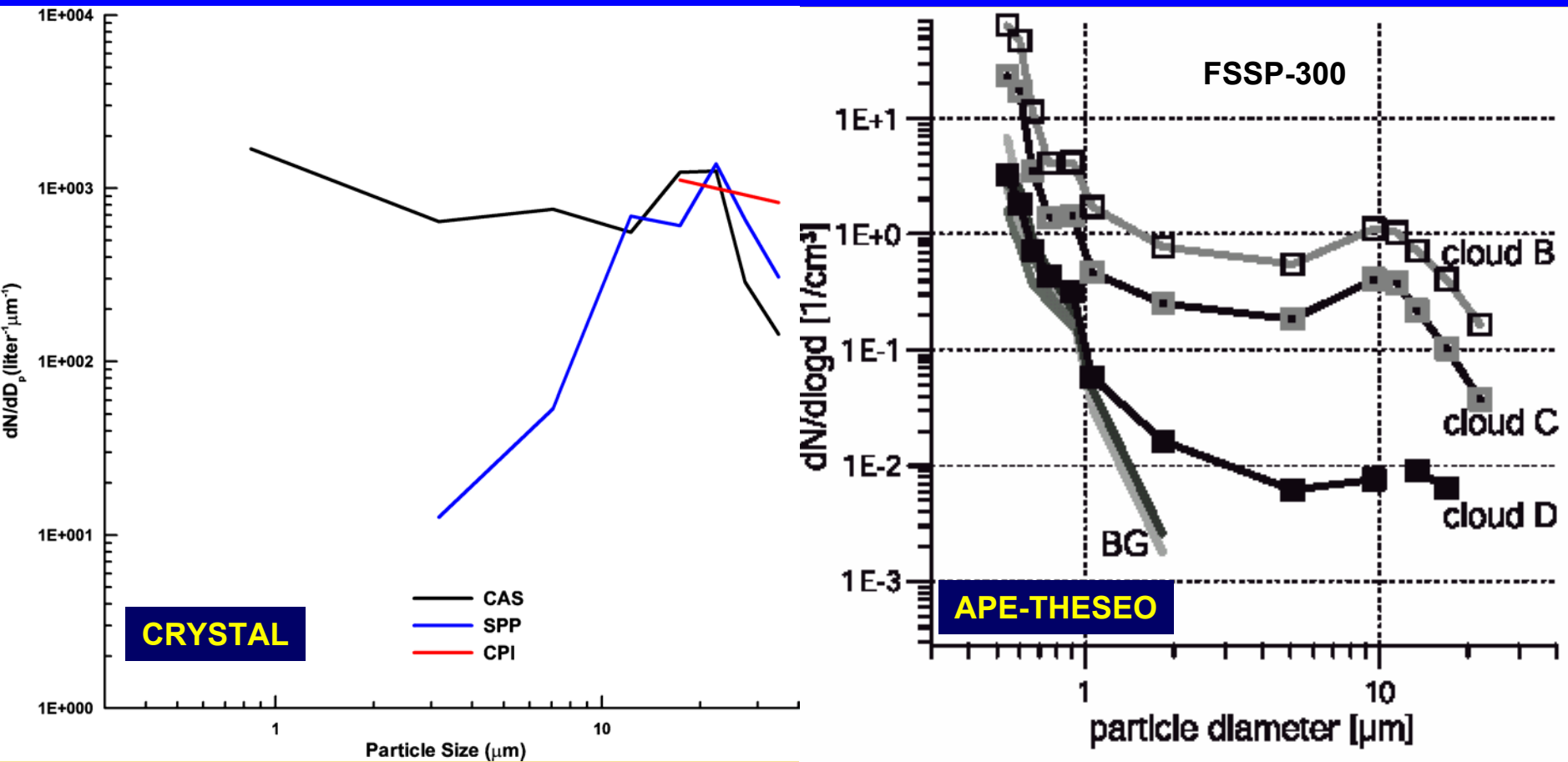
Cloud Spectra Composite Examples
CAPS and VIPS
July 26



Post-Project Laboratory Results - Droplets only



Comparison with Other Cirrus Studies



Thomas et al., 2002: In situ measurements of background aerosol and subvisible cirrus in the tropical tropopause region, *J. Geophys. Res.*, 107, 10.1029/2001JD001385.

Figure courtesy of S. Borrmann, Max Planck Institute for Chemistry, Mainz, Germany.

Location of Instruments

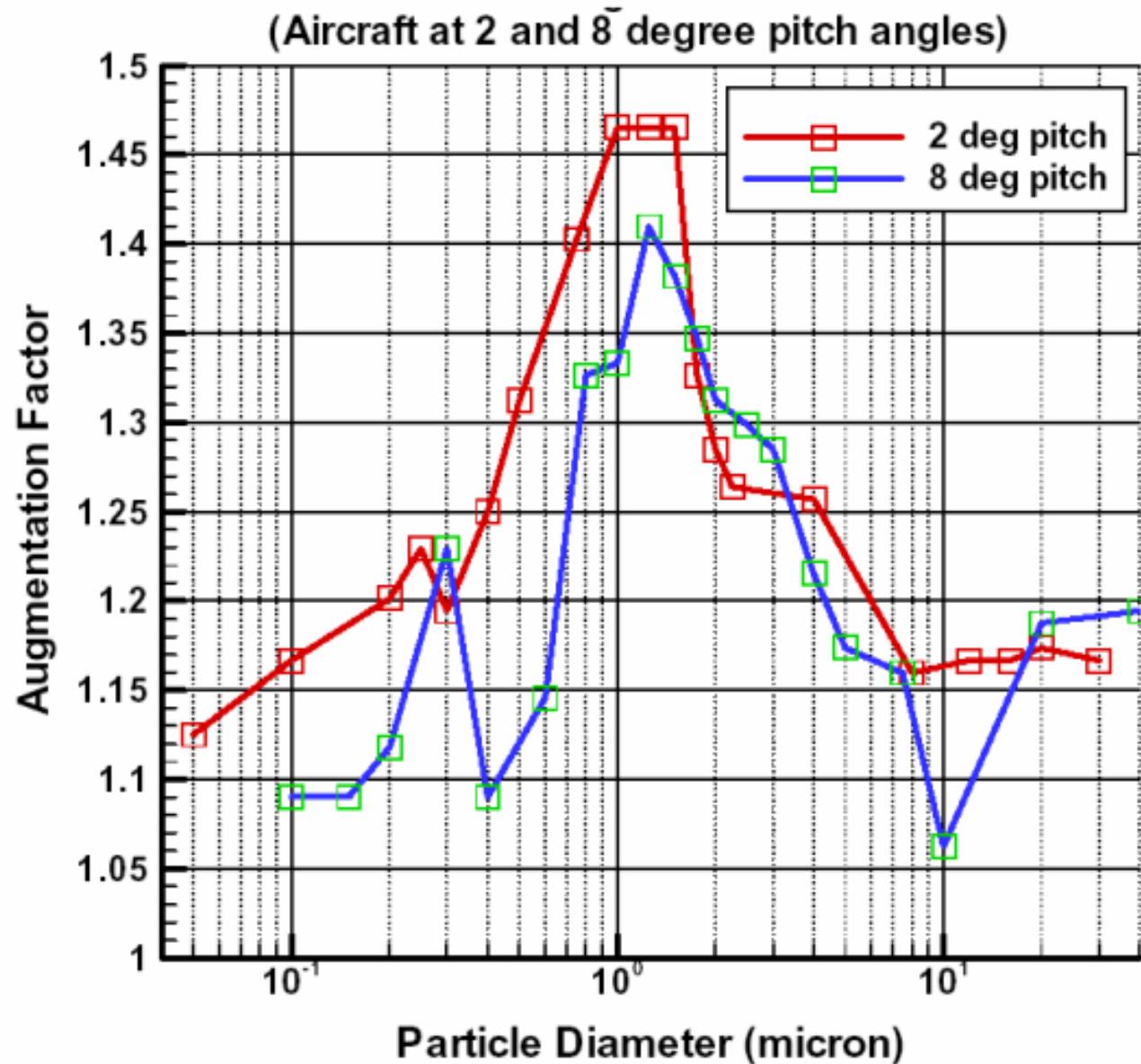


CIN, SPP-100, CPI

VIPS, HWAT, CAPS

Potential Airflow Effects

Preliminary Modeling Results - Inboard, Left Pylon (MASP location)



Composite Spectra Issues

- **Methodology for expressing variance in size overlap regions**
- **Instrument to select when there are large differences in size overlap regions**
- **Spatial/temporal averaging scales**
- **Others?**